This thesis describes the development of novel catalytic reaction-based detection and their application to flow injection (FI) spectrophotometric methods for ultratrace metals analysis. The reaction developed in this research is a catalytic oxidation reaction of $N,N$-dimethyl-$p$-phenylenediamine (DPD) with iron and/or copper in the presence of hydrogen peroxide. The application of this reaction has been validated as it could be applied to real samples. One of the applications of this reaction was the determination of dissolved and total amounts of iron contents in natural waters. As the reaction is very sensitive, it was also applied to the quantification of trace iron in ultrapure mineral acids. In these two cases, triethylenetetramine (TETA) was used as a masking agent for suppressing the interference from copper. By masking effect of TETA, a sequential determination of iron and copper in bottled-mineral drinking waters was successfully achieved.

The second detection reaction developed in this research is a catalytic oxidative coupling reaction of DPD with 1,3-phenylenediamine (mPD) with iron and/or copper in the presence of hydrogen peroxide. In this reaction, detailed studies of pH effect on sensitivity and selectivity for iron and copper detection was done by FI method. The selective and highly sensitive determination of iron and copper were accomplished under the optimal pH condition for their determination. The developed methods were successfully applied to the determination of iron and copper in tap and natural waters. Moreover, the developed detection reaction has the possibility for the determination of cobalt, manganese and chromium.

The third interesting catalytic reactions, the reduction reaction of indigo carmine and methylene blue by sulfide in alkaline solution, were also developed for nickel determination. According to the present results, these two reactions show the possibility for the quantification of trace amounts of nickel in water samples.

The present thesis will greatly contribute to improve the transition metal ion analysis and the clarification of the catalytic phenomena of trace metals in analytical chemistry.
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In view of original contents and creative results obtained in this research, the committee evaluated this dissertation as PhD degree’s worth of research.